How low will we go in fishing for dinner?

Though news accounts over the past decade have documented the crash of one major fishery after another, many consumers have witnessed no shortage of affordable fish. In large measure, that's because different fish are being marketed. Indeed, species once viewed as "trash" can now command $7 per pound or more.

Many resource economists have interpreted this trend to mean that while the most popular fish stocks are in jeopardy, a host of attractive alternatives stands ready to fill in. A new study by fisheries scientist Daniel Pauly of the University of British Columbia in Vancouver and his colleagues now comes to a dramatically different—and more dire—conclusion.

Those substitutes, they find, have been coming from progressively lower niches in the marine food web. With each successive drop, dramatically more fish become available.

Yet despite having made these shifts, and working harder, fishing fleets have not increased their tonnage of palatable catch. Moreover, the new data suggest that the food web's structure—the proportion of organisms at each level—is shifting.

"The ecological price we're paying for maintaining catch is getting higher and higher," Pauly says. Indeed, the findings argue that current world fishing rates are not sustainable, his team concludes in the Feb. 6 SCIENCE.

Ecologists measure an organism's niche in terms of its trophic level. In the sea, the base level contains mainly seaweeds and phytoplankton. These serve as food for level two organisms, whose predators, in turn, make up level three. And so it goes up the marine food web to its apex, killer whales at trophic level five.

Owing to taste preferences, humans have traditionally fished primarily from levels three and four, Pauly says. However, because such fish may derive their diet from a range of trophic levels, most commercial fish don't fall squarely into a single level. Rather, they have an intermediate designation, such as 4.6 for snapper, 3.5 for cod, 3.1 for herring, and 2.5 for sardines.

Pauly and his coworkers have now computed the annual average trophic level of the world's fishing catch. They did this by tracking down the trophic level of 220 fish and invertebrates and considering each species' share of the tonnage of a given year's fishing haul, as compiled by the United Nations, for 1950 through 1994. Their calculations show about a 0.1 decrease in trophic level per decade—to a current global average of about 3.1.

These data show that by overfishing the top predators, "we've eliminated the marine equivalent of lions and wolves and are moving towards the taking of rats, cockroaches, and dandelions," worries Elliott A. Norse of the Marine Conservation Biology Institute in Redmond, Wash. Moreover, he says, "by now moving to eliminate the top predators' prey and the prey of their prey, we may be further impeding [the top predators'] recovery."

Both concerns are "implicit in our findings," Pauly believes. "If we have fallen half a trophic level in 40 years or so, then we have already hammered the useful part of the food web."

The new study "is clever and meaningful . . . and I think that its conclusions are robust," says marine ecologist Paul K. Dayton of the Scripps Institution of Oceanography in La Jolla, Calif.

Gary Matlock, director of the National Marine Fisheries Service Office of Sustainable Fisheries in Silver Spring, Md., also thinks the new study's findings have a lot of merit. Clearly, he says, "the overfishing that has occurred on the upper trophic levels needs to be brought under control." According to the 1996 Sustainable Fisheries Act, he notes, his agency must develop a strategy by September to end such overfishing and to begin rebuilding affected U.S. stocks.

—J. Raloff

Protein switch curls bacterial propellers

Without its flagella, many a bacterium would truly be up a creek without a paddle.

A bacterium may have a dozen or so of these corkscrew-shaped tails that act as little propellers. A rotary motor protein at the base twirls each flagellum counterclockwise. To change course, a bacterium briefly reverses the flagellar rotation and then tumbles about until heading off in the new direction.

This quick switch alters not only the bacterium's path, but the shape of the flagellum as well. Now, an international team of researchers has determined what happens to the complex structure of a flagellum when the bacterium throws its motors into reverse.

Keiichi Namba of the International Institute for Advanced Research at the Matsushita Electric Industrial Co. in Seika, Japan, and his colleagues have obtained high-resolution, X-ray fiber diffraction patterns of the three-dimensional structure of bacterial flagella. Their images reveal a mechanism that enables a flagellum to switch from its ordinary loose-corkscrew shape, wound in one direction, to a curlier corkscrew wound in the opposite direction.

The team's report appears in the February NATURE STRUCTURAL BIOLOGY.

The findings represent "a dramatic step forward," says Donald L.D. Caspar of Florida State University in Tallahassee. "The bacterial flagellar system has been one of the most significant models of switching mechanisms in biological structures."

A bacterial flagellum is a complex structure made of a bundle of 11 protein strands that wrap gently around each other like the fibers in a rope. In the dramatic change of shape, the strands of a flagellum slide past each other.

The corkscrew structure arises from the mix of two different types of strands in the bundle. Like mirror-image spiral staircases, one type has an intrinsically left-handed twist and the other a right-handed twist. Bacteria genetically mutated to produce only one type of strand have straight flagella—which don't make very good propellers, Caspar notes.

When a normal, corkscrew flagellum reverses rotation, mechanical stress forces the interlocking protein strands to move past each other slightly and fasten together in different spots. "The slipping switch propagates over the entire length of a 10- to 15-micrometer-long flagellar filament within a few tens of milliseconds," says Namba. This speedy shape shift occurs without major rearrangement of the strands, which remain entwined in the same order.

This subtle slip-and-click mechanism accounts for another observation concerning the lengths of the individual strands. Each strand consists of a chain of protein subunits linked end-to-end like the cars of a train. The subunits in the loose corkscrew flagella are about 0.08 nanometer farther apart than those in the curlier tails.

In a conventional scheme of protein refolding, says Caspar, "it's very hard to visualize a structural change in a protein molecule that involves such a small displacement." The current mechanism can account for the tiny change, he adds, because the slippage causes the subunits on neighboring strands to mesh with only a slightly different spacing.

Namba expects that the switch might also be used in other motor proteins. He says that hemoglobin, the blood molecule that alters its structure when it binds to oxygen, also changes its overall shape without major rearrangements of its components.

Namba and his colleagues have already obtained even higher resolution images of flagellar filaments, which should show "the atomic detail of the subunit structure and subunit-subunit interactions," he says. "Once the crystal structure is solved and the atomic model is built, we will be able to look into the details of the slipping switch mechanism."

—C. Wu